(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 September 2002 (19.09.2002)

PCT

(10) International Publication Number
WO 02/073286 A1

(51) International Patent Classification[7]: G02B 26/08, 5/18

(21) International Application Number: PCT/US02/06715

(22) International Filing Date: 28 February 2002 (28.02.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/802,619 8 March 2001 (08.03.2001) US

(71) Applicant: SILICON LIGHT MACHINES [US/US]; 385 Moffett Park Drive, Suite 115, Sunnyvale, CA 94089 (US).

(72) Inventors: TOMITA, Akira; 929 Whitehall Lane, Redwood City, CA 94601 (US). AMM, David, T.; 178 Greenlees Drive, Kingston, Ontario K7K 6P5 (CA). DANEMAN, Michael, J.; 443 Gateway Drive, #109, Pacifica, CA 94044 (US). HUNTER, Jim; 253 Victor Avenue, Campbell, CA 95008 (US). STAKER, Bryan; 1619 Silacci Drive, Campbell, CA 95008 (US).

(74) Agents: HAVERSTOCK, Thomas, B. et al.; Haverstock & Owens LLP, 162 North Wolfe Road, Sunnyvale, CA 94086 (US).

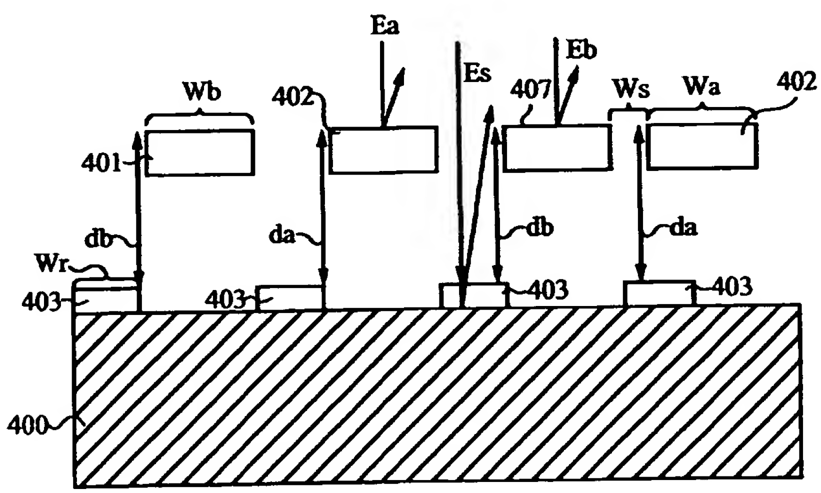
(81) Designated States *(national)*: CA, JP.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: HIGH CONTRAST GRATING LIGHT VALVE



(57) Abstract: A grating light valve has with a plurality of spaced reflective ribbons are spatially arranged over a substrate with reflective surfaces. The grating light valve is configure to optimize the conditions for constructive and destructive interference between beams reflected from an incident light source having a wavelenght λ. The grating light valve preferably has a set of movable active ribbons alternating between the set of stationary bias ribbons. The active ribbons and the bias ribbons are spatially separated over the substrate surface such that reflective regions of the substrate surface correspond to the spaces between the ribbons. The ribbons and reflective regions of the substrate optically and geometrically optimized for to generate the conditions for constrictive and destructive interference. Accordingly, the active ribbons are configured with reflective surface areas that are approximately equal to the sum of the surface areas of the bias ribbons and that of the refelective regions of the substrate. In operation, active ribbons are moved by a multiple of λ/4 to switch between the conditions for constructive and destructive interference.

WO 02/073286 A1

HIGH CONTRAST GRATING LIGHT VALVE

Field of the Invention:

The invention relates to grating light valve devices. More particularly, the present invention relates to grating light valve devices with an asymmetric configuration of movable ribbons for optimizing diffraction conditions.

Background of the Invention:

Recent developments in the miniaturization of various electro-mechanical devices, also known as micro machines, has led to the emergence of miniature diffraction gratings. One type of miniature diffraction grating is a grating light valve. A grating light valve is a device that is capable of alternating between the conditions for constructive and destructive interference with an incident light source λ to modulate the reflected light source between a minimum and maximum intensity value, preferably in a stepwise fashion. Grating light valves have applications in display, print, optical and electrical device technologies. Examples of a grating light valves and their uses are disclosed in the U.S. Patent 5,311,360, issued to Bloom et al., which is hereby incorporated by reference.

Referring to Figure 1a, the grating light valve construction as taught in the U.S. Patent 5,311,360, has a plurality of movable ribbons 100 that are spatially arranged over a substrate 102. The surfaces 104, corresponding to the ribbon tops and the regions of the substrate between the ribbons, are reflective. The surfaces 104 are made to be reflective by depositing a thin film of reflective material, such as silver or aluminum on the substrate 102 and the ribbons 100. The ribbons and the substrate structure are micro fabricated from a silicon-based materials. The height difference 103 between the reflective surfaces 104 of the substrate 102 and the reflective surfaces 104 of the ribbons 100 are configured to be $\lambda/2$ when the ribbons 100 are in the up position as shown in Figure 1a. When light having a wavelength λ impinges on the compliment of reflective surfaces 104, light that is reflected from the surfaces 104 of the substrate 102 and ribbons 100 will be in phase. Light which strikes the reflective surfaces 104 of the substrate 102 travels $\lambda/2$ further than the light striking the reflective surfaces 104 of the ribbons 100. Then the portion of light that is reflected back from the reflective surfaces 104 of the substrate 102 returns traveling an addition $\lambda/2$ for a total of one complete wavelength λ. Therefore, the compliment of the reflective surfaces 104 function as a mirror to the incident light source with a wavelength λ.

By applying an appropriate bias voltages across the ribbons 100 and the substrate 102, a portion of the ribbons 100 move towards and contact the substrate 102, as shown in Figure 1b. The thickness T_r of the ribbons 100 is designed to be $\lambda/4$ such that the distance 103' is also $\lambda/4$. When light having a wavelength λ impinges on surfaces 104 and 104' with the ribbons 100 in the down position, as shown in Figure 1b, the portion of light reflected from the surfaces 104' of the ribbons 100 will be out of phase with the portion of light

reflected from the surfaces 104 of the substrate 102, thereby generating the conditions for destructive interference. By alternating the ribbons between the positions for constructive interference, as shown in Figure 1a, and the positions for destructive interference, as shown in Figure 1b, the grating light valve is capable of modulating the intensity of reflected light from an impinging light source having a wavelength λ.

Summary of the Invention:

There have been several advances in grating light valve devices both in the fabrication processes and in design. For example, flat diffraction grating light valves and their advantages are described in the U.S. Patent No. 5,841,579 and the U.S. Patent No. 5,808,797, both issued to Bloom et al., the contents of which are incorporated by reference. Figures 2a-b illustrate cross sectional views of a flat diffraction grating light valve and its operation. Flat diffraction grating light valves, have at least two sets of alternating ribbons 206 and 207 that are approximately in the same reflective plane.

Referring to Figure 2a, the ribbons 206 and 207 are suspended over a substrates structure 202 by a distance 205. The ribbons 206 and 207 are provided with a reflective surfaces 204 and 205, respectively. Preferably, the surface of the substrate 202, or a portion thereof, also has a reflective surface 208. The reflective surfaces of the substrate 208 and the reflective surfaces of the ribbons 204 and 205 are preferably configured to be separated by a distance approximately equal to a multiple of λ/2 of the impinging light source. Thus the portion of light that is reflected from the compliment of surfaces 204, 205 and 208 are all phase, constructively interfere and the maximum intensity is observed. In operation, the flat diffraction grating light valve alternates between the conditions for constructive and destructive interference by moving the first set of ribbons 206 or the second set of ribbons 207 relative to each other by a distance corresponding to λ/4.

In one mode of operation, light is modulated by moving one set of alternating ribbons relative to a stationary set of alternating ribbons. The ribbons that are moved are referred to as the active ribbons and the stationary ribbons are referred to as the bias ribbons. The active ribbons are moved by any number of means including mechanical means, but are preferably moved by applying a sufficient bias voltage across the active ribbon and the substrate created Coulombic attractions and/or repulsions between the the active ribbons and the substrate.

Now referring to Figure 2b, when a sufficient bias voltage is applied across the active of ribbons 207 and the substrate 202, the ribbons 207 are displaced relative to the bias ribbons 206 by a distance 203 that is approximately equal to a multiple of λ/4. Accordingly, the portions of light that are reflected from the surfaces 205' of the active ribbons 207 will destructively interfere with the portion of light that are reflected of the surfaces 204 of the bias ribbons 206. It will be clear to one skilled in the art that a grating light valve may be configured to modulated an incident light source with a wavelength λ in other operative modes. For example, both sets of ribbons 206 and 207 may be configured to move and separate by multiples of λ/4 in order to alternate between the conditions for constrictive and

destructive interference.

While current designs of grating light valves have improved their operating efficiency and reliability, there is continued need to further optimized of grating light valve devices for use in display, print, optical and electrical device technologies.

In accordance with the instant invention a grating light valve has a diffraction cross section that is capable of interfering constructively and destructively with an incident light source having a wavelength λ. The grating light valve of the instant invention is configured to operated with any number of light sources, but is most useful for diffracting incident light sources with wavelengths between 300 and 3000 nanometers. The grating light valve preferably has a plurality of movable ribbons each coated with a reflective layer.

The plurality of moveable ribbons are comprised of at least two of sets of alternating ribbons. The ribbon in the first set have average widths W_a that are preferably 1 to 6 microns in the diffraction region of the device. The ribbons in the second set have average widths Wb that are preferably 0.5 to 5 microns in that diffraction region of the device. The ribbons of the first set and the ribbons of the second set are uniformly separated by an average width W_s of 0.5 to 2.0 microns in the diffraction region of the device.

The ribbons are suspended over reflective regions of a substrate element. The reflective regions of the substrate correspond to the spaces W_s between the alternating ribbons. In the constrictive interference position the reflective surface of the of ribbons are preferably in the same reflective plane and separated from the reflective regions of the substrate by a distance approximately equal to a multiple of $\lambda/2$ such that the compliment of reflective surface including the reflective regions of the substrate act as a mirror.

The diffraction efficiency and the contrast of the grating light device is improved by configuring the device to generate amplitudes of reflected light from the first set of ribbons that is substantially equal to the sum of the amplitudes of the reflected light from the second set of ribbons and the reflective light from the reflective regions of the substrate. Preferably, the amplitude matching is accomplished by making W_a equal to the sum of a with W_b and W_s within the diffraction region of the grating light valve and by providing the ribbons and the reflective regions of the substrate between the ribbons with the same reflective surfaces. Accordingly, in the destructive interference position, the compliment of reflective surfaces maximize cancellation of the reflected light and, hence, maximize the contrast of the grating light valve.

In operation, the first set of ribbons is moved by a distance equal to a multiple of $\lambda/4$ in order to switch between the conditions for constructive and destructive interference. Preferably, the first set of ribbons is move towards the reference surface of the substrate by applying a sufficient bias voltage across the first set of ribbons and the substrate element. Alternatively, both the first set and the second set of ribbons are move in opposite directions relative to the reference surface of the substrate to switch between the conditions for constructive and destructive interference.

Brief Description of the Drawings:

Figure 1a-b are cross sectional representations of a grating light valve with a reflective ribbons that are movable relative to the reflective surfaces of a substrate to alternated between the conditions for constructively and destructively interfere with an incident light source having a wavelength λ.

Figure 2 a-b are cross sectional representations of a flat diffraction grating light valve with two sets of alternating reflective ribbons that are movable relative to each other to alternate between the conditions for constructively and distractively interfere with an incident light source having a wavelength λ.

Figure 3 is a cross sectional representation of a grating light valve with reflective active ribbons and alternating reflective bias ribbons spatially arranged over a substrate with reflective regions between the ribbons.

Figure 4 illustrates a top schematic view of a grating light valve with asymmetric ribbons in accordance with the instant invention.

Figure 5 illustrates a grating light valve with reflective elements attached to a substrate with each of the reflective elements having spaced ribbons for generating the conditions for constructive and destructive interference with an incident light source having a having a wavelength λ.

Detailed Description of the Invention

Flat diffraction grating light valves, described above, which have at least two sets of movable ribbons are preferably over a single set of movable ribbons, for performance and manufacturing reasons that are detailed in the U.S. Patent No. 5,841,579. While the flat diffraction grating light valve is preferred, there are still several short comings that must be overcome to optimize the contrast and efficiency of the device.

One inefficiency in a flat grating light valve arises because of the spaces between the alternating active and bias ribbons. The spaces between the alternating active and bias ribbons are required because of manufacturing tolerances and for operation tolerances that allow the active ribbons move relative to the bias ribbons. As a result, a considerable portion of the incident light passes between the ribbons and impinges the regions of the substrate corresponding to the spaces. If these regions of the substrate surface are not properly construction to reflect the incident light source or are not properly phase matched with the active and the bias ribbons, then the maximum efficiency of the device is not achieved and the maximum contrast will not be observed.

In other words to optimize the contrast and efficiency of a light grating valve, light that is reflected from interference surfaces within the diffraction region of a grating light valve must be completely in phase for constructive interference and completely out of phase for destructive interference. Further, the interfering light reflected from the surfaces that are interfering must have the same amplitude to achieve total cancellation of the light.

Thus to improve the efficiency of the light grating device and to optimized the contrast of the modulated light, the instant invention provides for reflective surfaces on the

substrate in the regions corresponding to the spaces between the alternating ribbons which are matched to the bias and active ribbons. Preferably this is accomplished by providing reflective surfaces on the ribbons and on the regions of the substrate between the ribbons which have the same reflectivity. This goal is further accomplished by providing an asymmetric ribbon configuration such that the reflective surface area of interfering surfaces are matched.

Figure 3 show a simplified cross sectional representation of a flat grating light valve. The grating light valve has a set of bias ribbons 401 and a set of active ribbons 402. The device is configured to constructively and destructively interfere with an incident light source (not shown) having a wavelength λ. In order to maximized light E_a and E_b that is reflected from the top surface of the ribbons 401 and 402, the ribbons 401 and 402 preferably form a single reflective plane. Further, to maximized the light Es that is reflected from regions 403 of the substrate, the distances da and db are preferably a multiple of $\lambda/2$.

According to the previous flat grating light valve designs, the widths Wb of the bias ribbons 401 and the widths Wa of the active ribbons are approximately the same, within manufacturing tolerances of ± 10 %. In operation the active ribbons 402 are moved toward the substrates 400 by a distance that is equal to a multiple of $\lambda/2$ such that the portions of the incident light E_b that are reflected from the bias ribbons 401 and the portions of the incident light Ea that are reflected from the active ribbons 402 are out of phase 403 and destructively interfere. In this case, even if E_b and E_b completely cancel the total light that is reflected will still include a contribution from Es and, therefore, the contrast is not optimized.

In order to optimized the condition for destructive interference and, therefore, optimize the contrast of the grating light valve, the grating light valve of the instant invention utilizes ribbons that exhibit asymmetric reflection amplitudes. Preferably, the ribbons are configured such that the amplitude of the incident light that is reflected by the set of active ribbons is substantially matched to the amplitude of incident light that is reflected by the sum of the set of bias ribbons and reflective regions of the substrate. Preferably, all of the reflective surfaces have approximately the same reflectivity and the active ribbons have a reflective surface areas that are approximately equal to the sum of the reflective surface areas of the bias ribbons and the reflective regions of the substrate.

The ribbons are preferably elongated and rectangular-like in shape. Further, the ribbons are preferably uniformly spaced. Accordingly, the asymmetric reflectivity of the ribbons is preferably achieved by making the average width W_a each of the active ribbons greater than the average width W_b each of the basis ribbons such that the sum of W_b and the spaces W_s between each of the alternating active and bias ribbons is approximable equal to W_a. Most preferably, the widths of the active ribbons W_a are made to be 1 unit wider than the widths W_b of the bias ribbons and, therefore, the widths W_s of the spaces between the alternating active and bias ribbons is approximately equal to1 unit.

Figure 4 shows a schematic representation of a grating light valve configured with sets of asymmetric ribbons 501 and 503, in accordance with the instant invention. The

asymmetric ribbons are uniformly spaced by a distance W_s and the average widths W_a of active ribbons 501 are approximately equal to the width W_b of the basis ribbons and the spacings W_s. The ribbons 501 and 503 are co-planar in the absence of and applied voltage. To place the ribbons in the condition for destructive interference with an incident light source having a wavelength λ, the active ribbons 501 are displaced towards the substrate 500 by a distance approximately equal to a multiple of $\lambda/4$.

Figure 5 shows a schematic representation of a grating light valve 600 in accordance with the instant invention. The grating light value 600 has at least two reflective elements 601 and 602 that are attached to a substrate element 603. Each of the reflective elements 601 and 602 has a plurality of ribbons which are suspended over the substrate surface 603 and are capable of being moved relative to each other to constructively and destructively interfere with light source having a wavelength λ which is incident on the diffraction region 605 of the device 600. Preferably the regions of the substrate 607 between the ribbons and in the diffraction region 605 are also reflective. The total reflective surface area of the reflective element 601 is approximately equal to the total reflective surface area of the reflective element 602 and the reflective surface area of the substrate regions 607 corresponding to the diffraction region 605 of the device 600.

In operation the ribbon of the reflective elements 601 and 602 are substantial co-planar and suspended above the reflective regions 607 of the substrate 603 by a distance equal to a multiple of $\lambda/2$ to achieve the condition for constructive interference and maximum brightness. To achieve the condition for destructive interference, the ribbons of the reflective element 601 are moved toward the substrate by a distance that is equal to $\lambda/4$, as described in detail above.

The present invention has been described in terms of specific embodiments incorporating details to facilitate the understanding of the principles of construction and operation of the invention. Such references, herein, to specific embodiments and details thereof are not intended to limit the scope of the claims appended hereto. It will be apparent to those skilled in the art that modifications can be made in the embodiment chosen for illustration without departing from the spirit and scope of the invention.

What is Claimed is:

1. A grating light valve comprising a first set of ribbons each with a first average width W_a and second set of ribbons each with a second average width W_b, wherein the ribbons of the first set alternate between the ribbons of the second set and wherein the first set and the second set of ribbons are configured to move relative to each other to constructively and destructively interfere with an incident light source having a wavelength λ.

2. The grating light valve of claim 1, wherein the ribbons of the first set and the ribbons of the second set are separated by an average spacing W_s.

3. The grating light valve of claim 1, wherein W_a is approximately equal to the sum of W_b ans W_s.

4. The grating light valve of claim 3, wherein the first set and the second set of ribbons are attached to a substrate element and suspended over a reference surface of the substrate element.

5. The grating light valve of claim 2, wherein the top surfaces of the ribbons in the first set and the top surfaces of the ribbons in the second set and regions of the reference surface between the ribbons of the first set and the second set have reflective surfaces with reflectivities greater than 50 %.

6. The grating light valve of claim 5, wherein the reflective surfaces comprise Aluminum.

7. The grating light valve of claim 4, wherein the first set of ribbons is configure to move a multiple of $\lambda/4$ relative to the reference surface of the substrate by applying a bias voltage across the first set of ribbons and the substrate element.

8. The grating light valve of claim 7, wherein the second set of ribbons is configure to

move a multiple of $\lambda/4$ relative to the reference surface of the substrate by applying a bias voltage across the second set of ribbons and the substrate element.

9. The grating light valve of claim 5, wherein the reflective surfaces have similar reflectivities and wherein the reflective surface areas E_a of the ribbons in the first set, the reflective surface areas E_b of the ribbons in the second set and the reflective surface areas E_s of the regions of the reference surface between the ribbons are configured such that E_a is approximately equal to the sum of E_b and E_s, E_b is greater than or equal to E_s and E_s is greater than zero.

10 The grating light device of claim 1, wherein the average width W_a is in the range of 1 to 6 microns, the average width W_b is in the range of 0.5 to 5 microns and average spacing W_s is in the range of 0.5 to 2.0 microns.

11. A grating light valve comprising a diffraction region comprising a first set of ribbons each with a reflective surface area E_a and second set of ribbons each with a reflective surface area E_b, wherein the first set and second set of ribbons are alternating and spaced over a reference surface with a reflective surface regions having reflective surface areas E_s between each alternating ribbon of the first set and second set and wherein E_a is approximately equal to the sum of E_b and E_s, E_b is greater than or equal to E_s and E_s is not equal to zero.

12. The grating light valve of claim 12, wherein the ribbons of the first set and the ribbons of the second set are elongated, wherein the ribbons of the first set each have and average width W_a , the ribbons of the second set each have and average width W_b and alternating ribbons of the first set and second set are separated abt an average distance W_s.

13. The grating light valve of claim 13, wherein W_a is approximately equal to the sum of W_b and W_s.

14. The grating light valve of claim 12, wherein the top surfaces of the ribbons in the first set the top surfaces of the ribbons in the second set and regions of the reference surface between the alternating ribbons of the first set and the second set have reflective metallized layers.

15. The grating light valve of claim 15, wherein the reflective metallized layers comprise Aluminum.

16. The grating light valve of claim 13, wherein the first set of ribbons is configure to move by a move a multiple of $\lambda/4$ relative to the reference surface of the substrate by applying a bias voltage across the first set of ribbons and the substrate element.

17. The grating light valve of claim 17, wherein the second set of ribbons is configure to move a multiple of $\lambda/4$ relative to the reference surface of the substrate by applying a bias voltage across the second set of ribbons the reference surface.

18. A method of modulating light with a wavelength λ a comprising the steps of:

a. suspending a first set of reflective ribbons by a first distance corresponding to a multiple of $\lambda/2$ over a reference surface with reflective regions, wherein each ribbon of the first set has a first reflective cross section ;

b. suspending a second set reflective ribbons by a second distance corresponding to a multiple $\lambda/2$ over the reference surface, wherein each ribbon of the second set has a second reflective cross section and wherein the first set and the second set of ribbons are spatially arranged such that the ribbon of the first set and the second set are alternating and spaced with reflective regions of the reference surface aligned with the spaces between the ribbon of the first set and the second set of ribbons;

c. shining a light an incident light source with a wavelength λ on the reflective surfaces of the first set of ribbons and the second set of ribbons; and

d. moving the first set of reflective ribbons relative to the second set of reflective

ribbons by a multiple of distance $\lambda/4$.

19. The method of claim 18, wherein the step of moving the first set of reflective ribbons relative to the second set of reflective ribbon is accomplished by applying a sufficient bias to at least one set of the reflective ribbons.

20. The method of claim 18, wherein the incident light source has a wavelength between 300 and 4000 nanometers.

21. An apparatus for modulating light with a wavelength λ, the apparatus comprising:
   a. means for reflecting light, the means for reflecting light comprising a first set of ribbons each with a first average width W_a and second set of ribbons each with a second average width W_b,
   b. means for shining a light with a wavelength λ on the reflective surfaces of the first set of ribbons and the second set of ribbons; and
   c. means for alternating the first set of reflective ribbons relative to the second set of reflective ribbon by a multiple of distance $\lambda/4$.

22. The apparatus of claim 22, wherein the means for alternating the first set of reflective ribbons relative to the second set of reflective ribbon by a multiple of distance $\lambda/4$ comprises a bias voltage source that is applied to at least one set of the reflective ribbons and a reference surface.

23. The apparatus of claim 22, wherein the means for shining a light with a wavelength λ on the reflective surfaces of the first set of ribbons and the second set of ribbons comprises light with a wavelength between 300 and 4000 nanometers.

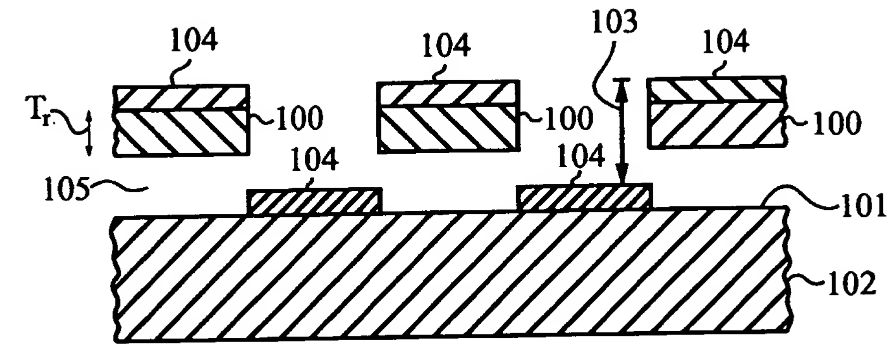

104
104
103
104
T_r
100
100
100
104
104
105
101
102

Fig. 1A

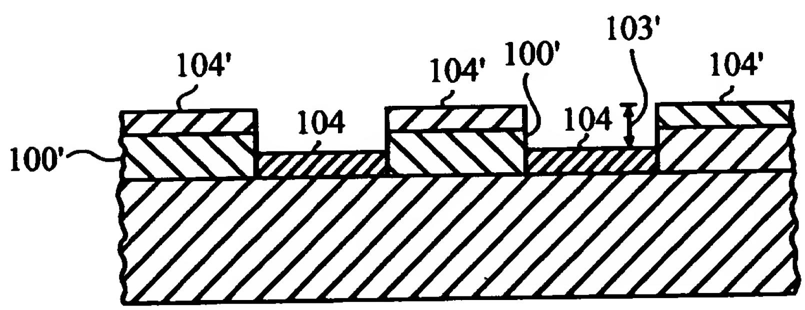

104'
104'
100'
103'
104'
104
104
100'

Fig. 1B

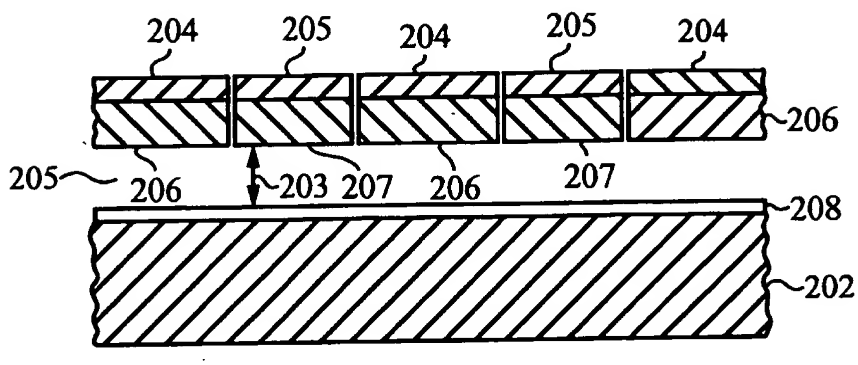

204
205
204
205
204
206
205
206
203
207
206
207
208
202

Fig. 2A

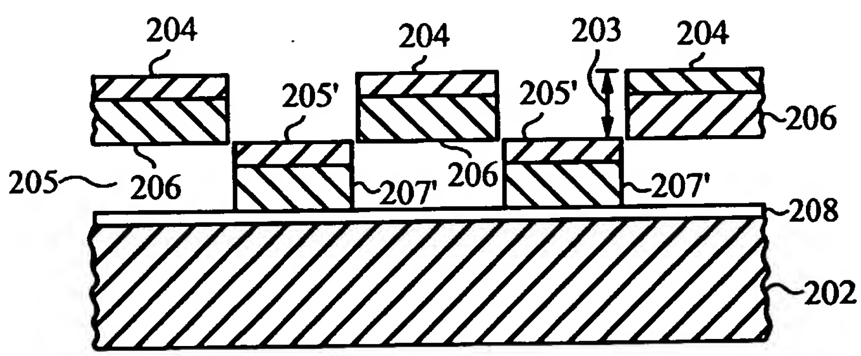

204
204
203
204
205'
205'
206
205
206
207'
206
207'
208
202

Fig. 2B

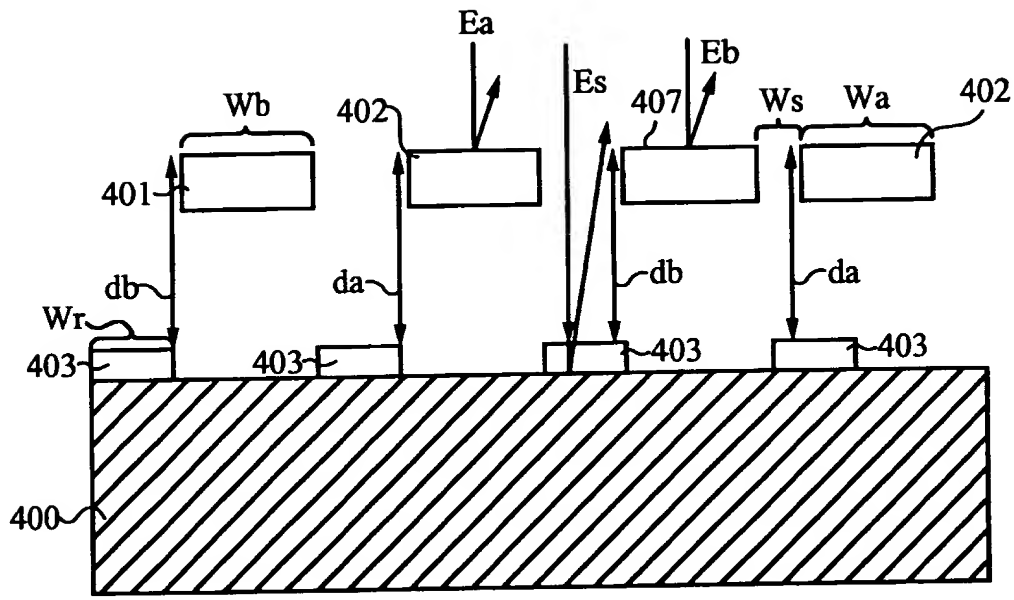


Fig. 3

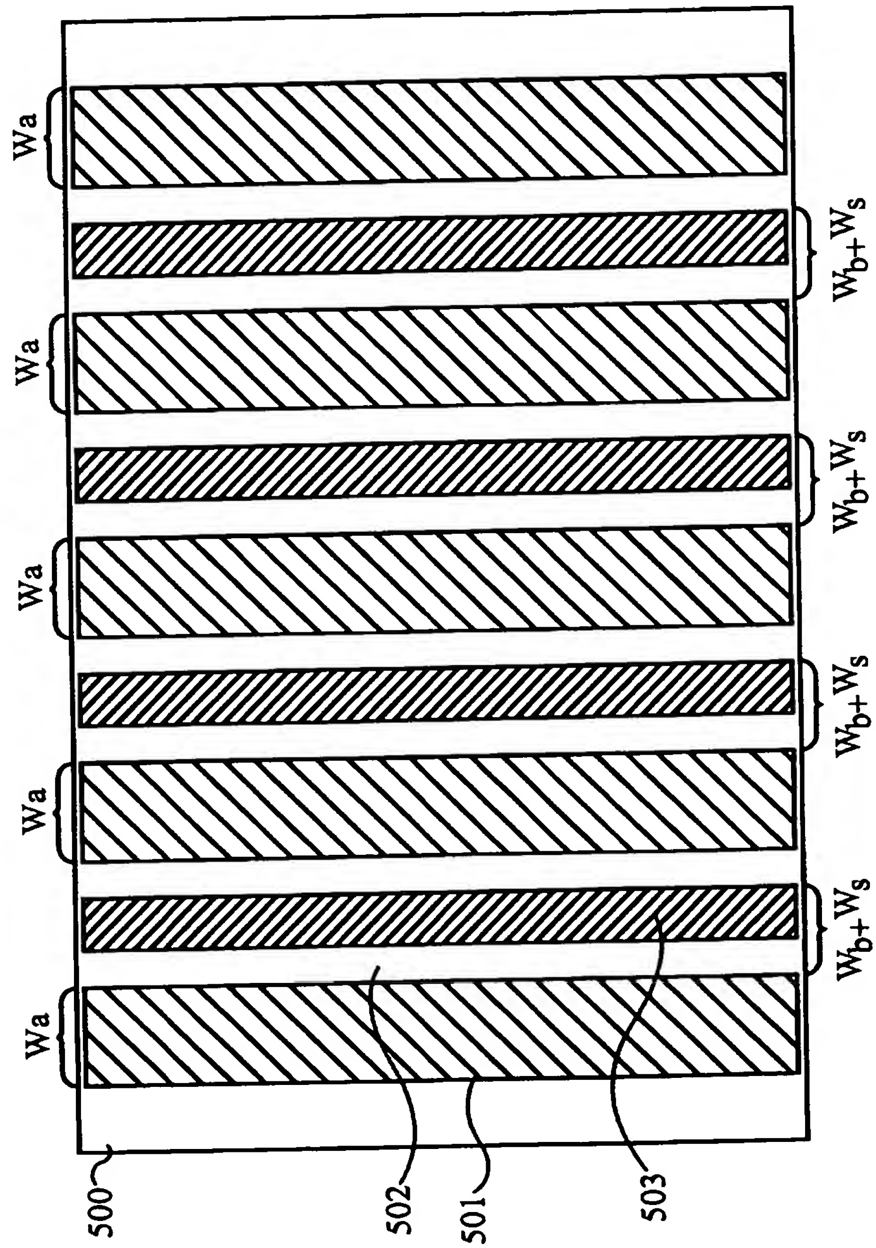


Fig. 4

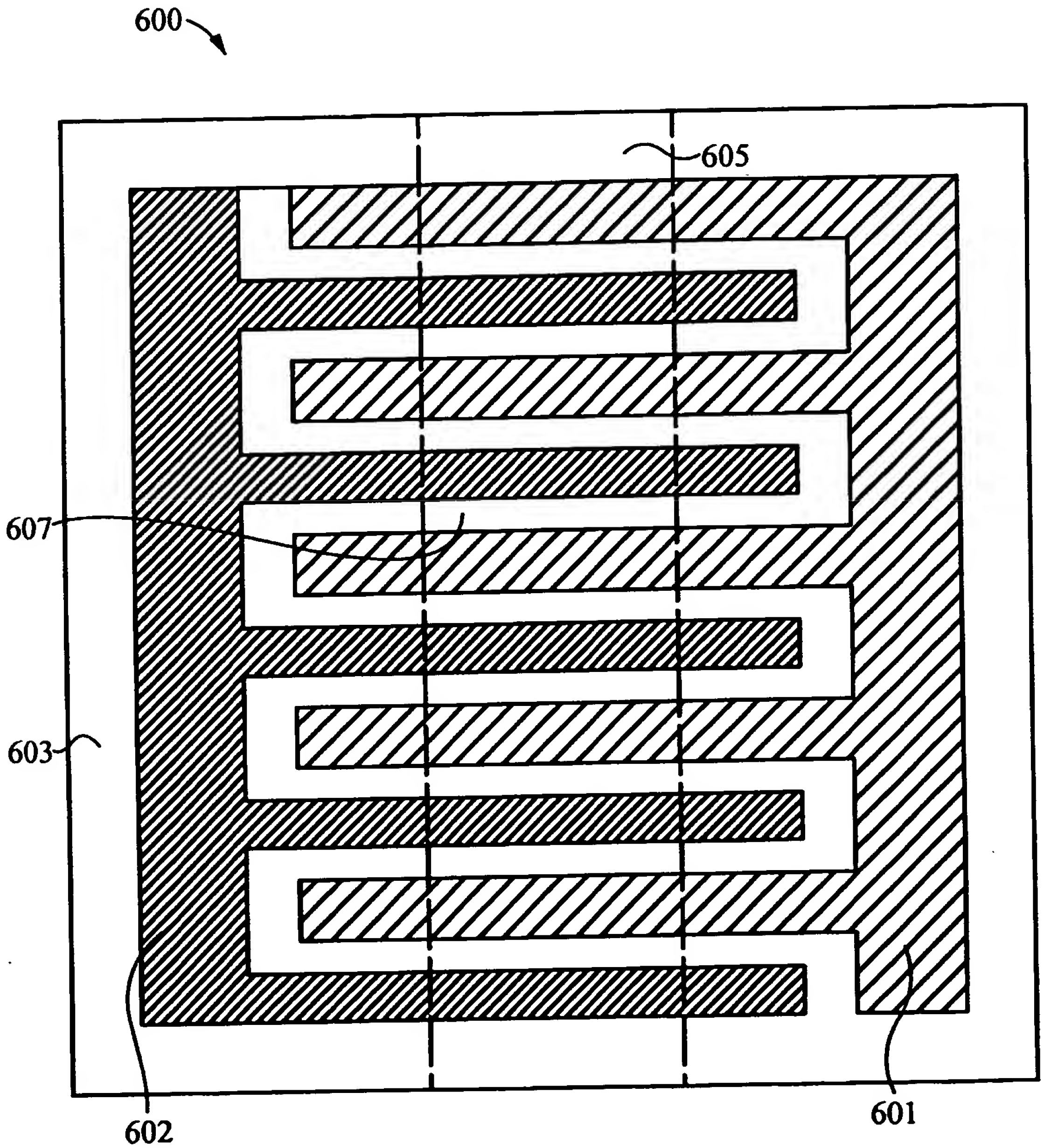


Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 02/06715

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02B26/08 G02B5/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC, COMPENDEX, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 311 360 A (BLOOM DAVID M ET AL) 10 May 1994 (1994-05-10) cited in the application abstract; claims 1,9,21,24,34,35; figures 3-6 column 3, line 31 -column 4, line 6 column 5, line 53 - line 60 column 6, line 18 - line 29 column 6, line 35 - line 41 column 8, line 63 -column 9, line 45 --- -/--	1-7, 19-22

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 June 2002	28/06/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Michel, A

[redacted]national Application No
PCT/US 02/06715

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 808 797 A (BLOOM DAVID M ET AL) 15 September 1998 (1998-09-15) cited in the application claim 2; figures 3-6 column 3, line 34 -column 4, line 2 column 5, line 45 - line 52 column 6, line 9 - line 30 column 8, line 45 -column 9, line 21 ---	1-7, 19-22
X	US 5 841 579 A (BLOOM DAVID M ET AL) 24 November 1998 (1998-11-24) cited in the application abstract; claims 1,4,6,7,9; figures 4,5,9 column 1, line 25 - line 56 column 2, line 18 - line 28 column 3, line 41 - line 62 column 5, line 36 - line 44 column 6, line 55 - line 64 column 6, line 65 -column 8, line 18 ---	1-7,11, 19,20,22
P,X	US 6 169 624 B1 (BLOOM DAVID M ET AL) 2 January 2001 (2001-01-02) abstract; claims 1-3,12,13,22,26,30; figures 1A,1B,3 column 2, line 30 -column 3, line 2 column 3, line 12 - line 33 ---	1-7,19, 20,22
A	APTE R B ET AL: "DEFORMABLE GRATING LIGHT VALVES FOR HIGH RESOLUTION DISPLAYS" TECHNICAL DIGEST, IEEE SOLID-STATE SENSOR & ACTUATOR WORKSHOP, NEW YORK, NY, US, 1994, pages 1-6, XP000884461 the whole document ---	1-22
A	SENE D E ET AL: "Polysilicon micromechanical gratings for optical modulation" SENSORS AND ACTUATORS A, ELSEVIER SEQUOIA S.A., LAUSANNE, CH, vol. 57, no. 2, 1 November 1996 (1996-11-01), pages 145-151, XP004073451 ISSN: 0924-4247 paragraphs '0001!,'0006!; figures 1,3,4 ---	1-22

-/--

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	AMM D T ET AL: "INVITED PAPER: GRATING LIGHT VALVETM TECHNOLOGY: UPDATE AND NOVEL APPLICATIONS" 1998 SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS. ANAHEIM, CA, MAY 17 - 22, 1998, SID INTERNATIONAL SYMPOSIUM DIGEST OF TECHNICAL PAPERS, SANTA ANA, CA: SID, US, vol. 29, 1998, pages 29-32, XP000956146 ISSN: 0098-966X the whole document -----	1-22

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 02/06715

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 5311360	A	10-05-1994	WO	9627810	A1	12-09-1996
			AT	208048	T	15-11-2001
			AU	4118693	A	29-11-1993
			CA	2133335	A1	11-11-1993
			DE	69331056	D1	06-12-2001
			EP	0638177	A1	15-02-1995
			ES	2164661	T3	01-03-2002
			JP	2002503351	T	29-01-2002
			US	5459610	A	17-10-1995
			WO	9322694	A1	11-11-1993
			US	5677783	A	14-10-1997
			US	6219015	B1	17-04-2001
			US	5808797	A	15-09-1998
US 5808797	A	15-09-1998	US	6219015	B1	17-04-2001
			US	5677783	A	14-10-1997
			US	5459610	A	17-10-1995
			US	5311360	A	10-05-1994
			AT	217094	T	15-05-2002
			CA	2243347	A1	24-07-1997
			EP	0875010	A2	04-11-1998
			JP	2001518198	T	09-10-2001
			WO	9726569	A2	24-07-1997
			WO	9627810	A1	12-09-1996
			AT	208048	T	15-11-2001
			AU	4118693	A	29-11-1993
			CA	2133335	A1	11-11-1993
			DE	69331056	D1	06-12-2001
			EP	0638177	A1	15-02-1995
			ES	2164661	T3	01-03-2002
			JP	2002503351	T	29-01-2002
			WO	9322694	A1	11-11-1993
US 5841579	A	24-11-1998	AT	192241	T	15-05-2000
			AU	5981196	A	30-12-1996
			DE	69607960	D1	31-05-2000
			DE	69607960	T2	17-08-2000
			DK	830624	T3	25-09-2000
			EP	0830624	A1	25-03-1998
			ES	2147380	T3	01-09-2000
			GR	3033806	T3	31-10-2000
			JP	10510374	T	06-10-1998
			JP	3164824	B2	14-05-2001
			NO	975696	A	05-12-1997
			PT	830624	T	31-08-2000
			WO	9641217	A1	19-12-1996
US 6169624	B1	02-01-2001	AU	1653701	A	05-03-2001
			AU	6531400	A	05-03-2001
			AU	6625700	A	05-03-2001
			EP	1203245	A2	08-05-2002
			EP	1203246	A1	08-05-2002
			EP	1203463	A2	08-05-2002
			WO	0111394	A1	15-02-2001
			WO	0111419	A2	15-02-2001
			WO	0111395	A2	15-02-2001